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METHODS OF PROPAGATING RIBES IN NUTRIENT SOLUTION FOR USE AS TEST PLANTS

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At Berkeley, Calif., the Division of Plant Disease Control has developed methods for the germination of Ribes seed and the greenhouse propagation of Ribes (currants and gooseberries) in soil and in nutrient solution. The purpose of this work has been to provide a stock of uniformly vigorous plants for tests in the chemical eradication of Ribes. A description of the method of propagation in nutrient solution is presented in this circular for the convenient reference of those in the Bureau who may have occasion to propagate other woody plants by that method.

Collection of Seeds

Thoroughly ripe fruits from vigorous plants are selected for seed. Viability of the seeds is best preserved by immediate extraction from the pulp. The pulp and the seeds are detached by repeated rubbing and washing in a cheesecloth bag. After the preliminary cleaning the seeds are placed in a large glass jar and the last of the pulp is removed by repeated washing and decantation. The cleaned and graded seeds are dried on cheesecloth in the shade in a cool place, and stored air-dry at 2.5° C. in corked vials.

If the seeds cannot be immediately extracted, the fruits are dried in a cool, dry place until they can be moved to a room in which the temperature is 2.5° C. Direct exposure of Ribes fruits to strong sunlight or dehydration at high temperatures reduces seed viability. Seed extraction from dried fruits is accomplished by soaking the fruits in water over night and then proceeding as with fresh fruits.

Germination of Seed

Seeds of most species of Ribes are dormant when mature, and require moist storage at low temperature before germination will occur. The most satisfactory stratification medium is moist river sand which has been sieved

¹ The authors gratefully acknowledge the cooperation of the College of Agriculture (specifically, the Division of Forestry and the Division of Plant Nutrition), and the Department of Botany, University of California, whereby greenhouse facilities and technical assistance have been furnished for the conduct of this work.

through 14-mesh screen and autoclaved. To protect the cultures from damage due to fungi powdered cupric oxalate ($\text{Cu}(\text{COO})_2 \cdot \frac{1}{2}\text{H}_2\text{O}$) is sprinkled evenly over the surface of the sand at the rate of 6 grams per square foot.²

The best stratification temperature for many species of *Ribes*, including *R. petiolare*, *R. cereum*, *R. nevadense*, and *R. roezli*, is 2.5° C. The most satisfactory stratification period for these species ranges from 8 to 16 weeks, varying with the species and with different lots of seed of the same species. Other species, including *R. inerme*, *R. lacustre*, and *R. viscosissimum*, are best stratified at 0° C. for periods of 8 to 20 weeks.

When seedlings in germination cultures are 4 to 6 weeks old, the healthy, vigorous plants are transplanted to soil in tarred-paper planting pots, or they may be transferred at that time, or any subsequent time, to the nutrient cultures. The most satisfactory soil for greenhouse propagation of *Ribes* is a very fine sandy loam collected in the coniferous forests of the Sierra Nevada Mountains.

Culture of Plants in Nutrient Solution

The containers used for the nutrient solution are 1-gallon stone crocks 7½ inches high and 7⅝ inches in outside diameter. These crocks are set on tables equipped with side boards 12 inches high. The spaces between crocks are then packed with moist Sphagnum moss, which tends to keep the solutions cool and to humidify the air in the greenhouse. (Fig. 1, A.)

Inverted circular tin cake pans 9 inches in diameter and 1 inch deep are used to cover the crocks. A ¼-inch slot is cut radially through the rim of each pan for a distance of 1½ inches. The slot permits introduction of a rubber tube which connects with a glass aerator to be described later. In the center of the pan a hole is cut to fit a 2¼-inch flat cork. A ½-inch hole is bored in the center of the cork to allow for insertion of the plant. (Fig. 1, C.) The corks are split into halves to permit introduction of stems of plants whose root systems are too large to be threaded through the hole.

During hot, dry weather, when the air temperature would otherwise be too high and the humidity too low, an overhead spray system is operated for several hours each day. The spray nozzles are set in a line about 4 feet above the centers of the culture tables and are so spaced that, when the water is turned on, a very fine mist envelopes the entire aerial parts of the plants.

Aeration of the nutrient solution is an important feature of the culture of the plants. Air under about 5 pounds pressure is washed by bubbling it through water in a closed tank packed with 1-inch mesh crushed rock. (Fig. 1, B and B₁.) The air is led from the washer to the greenhouse tables through ¼-inch iron pipe. At each crock an outlet is provided which delivers a continuous stream of fine air bubbles into the nutrient solutions through a sintered glass aerator. (Fig. 1, A and C.)

² Quick, C. R. Chemical control of harmful fungi during stratification and germination of seeds of *Ribes roezli*. *Phytopathology* 26: 694-697. 1936.

The aerators are Pyrex glass tubes plugged with sintered powder of the same material. Their merits and the details of their construction are fully reported by Furnstal and Johnson.³

Ribes seedlings about 4 inches high are usually selected for transference to nutrient solution. Much larger plants can be successfully transplanted, but it is easier to handle plants without injury if the root systems are not very large. Regardless of size, plants are never pulled or dug out of the soil with tools. Instead, the soil is washed away from the roots by a gentle stream of tap water. The washed plant is fixed into position in the crock by inserting it between halves of a split cork packed with cotton wool. The level of the nutrient solution in the crock is then adjusted so that the root crown is just covered.

If Ribes plants are cultured in nutrient solution for long periods, their root systems will continue to develop until the crocks become filled. When this happens it is difficult to maintain proper aeration of the solution. Periodic root pruning is therefore advisable. Root pruning is done with shears, by cutting off all roots at a distance of 5 to 6 inches below the root crown. After the roots have been cut, the remaining root mass is washed with a fine, hard stream of tap water to dislodge and wash out the dead tissue that has been accumulated. If any top pruning is contemplated, it is done at this time. The stumps of pruned stems are sealed with grafting wax, but no attention is given the ends of the pruned roots. After pruning, the plants are returned to the nutrient solution. It is best to prune when the air can be kept cool for several days. Partial shade for a few days after pruning is also desirable.

The composition of the nutrient solution and that of the stock solutions from which it is made are given in the accompanying table. The nutrient solution is prepared by adding 1 milliliter of each of the stock solutions to 1 liter of final solution. Distilled water is used for making all solutions.

The supplementary solution is one that is used by the Division of Plant Nutrition of the University of California to supply traces of certain elements which may be absent from the C. P. materials used in making nutrient solutions. It is known that traces of some of these elements are essential to the nutrition of many higher green plants. It is not yet known if traces of all the elements represented are required by plants, but evidence now available seems to favor that view.^{4, 5, 6}

³ Furnstal, A. H., and Johnson, B. Preparation of sintered Pyrex glass aerators for use in water culture experiments with plants. *Plant Physiol.* 11: 189-194. 1936.

⁴ Hoagland, D. R. Mineral nutrition of plants. *Ann. Rev. Biochem.* 1: 618-636. 1932.

⁵ Hoagland, D. R., and Snyder, W. C. Nutrition of strawberry plant under controlled conditions. *Amer. Soc. Hort. Sci. Proc.* 30: 288-296. 1933.

⁶ Steward, F. C. Mineral nutrition of plants. *Ann. Rev. Biochem.* 4: 519-544. 1935.

Tartaric acid is included in stock solution no. 5 to retard precipitation of iron hydroxide during storage of this solution.

When the plants are growing vigorously, it sometimes becomes necessary to replenish the iron in the nutrient solution by further additions of stock solution no. 5 in the proportion of 1 ml. per liter.

Distilled water is added to the crocks as needed to replace that taken out by transpiration. The entire nutrient solution is usually replaced once a month, to avoid depletion.

NUTRIENT SOLUTION FOR RIBES

No.	Composition of stock solutions			Composition of nutrient solution expressed as moles per liter
	Material	Formula	Grams per liter of stock solution	
1	Calcium nitrate	$\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	590	0.0025
2	Potassium nitrate	KNO_3	172	0.0017
3	Magnesium sulphate	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	160	0.00065
4	Potassium phosphate (diH)	KH_2PO_4	14	0.0001
5	Potassium ferric tartrate	$\text{KFeOC}_4\text{H}_4\text{O}_6$	10.6	0.000033
	Tartaric acid	$\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	6.2	0.000033
6	Supplementary solution	See below		

The composition of the supplementary solution (stock solution no. 6) is given herewith:

Material	Formula	Grams per 18 liters
Aluminum sulphate	$\text{Al}_2(\text{SO}_4)_3$	1.0
Potassium iodide	KI	0.5
Potassium bromide	KBr	0.5
Titanium dioxide	TiO_2	1.0
Stannous chloride	$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$	0.5
Lithium chloride	LiCl	0.5
Manganese chloride	$\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$	7.0
Boric acid	H_3BO_3	11.0
Zinc sulphate	ZnSO_4	1.0
Cupric sulphate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	1.0
Nickel sulphate	$\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$	1.0
Cobaltous nitrate	$\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	1.0

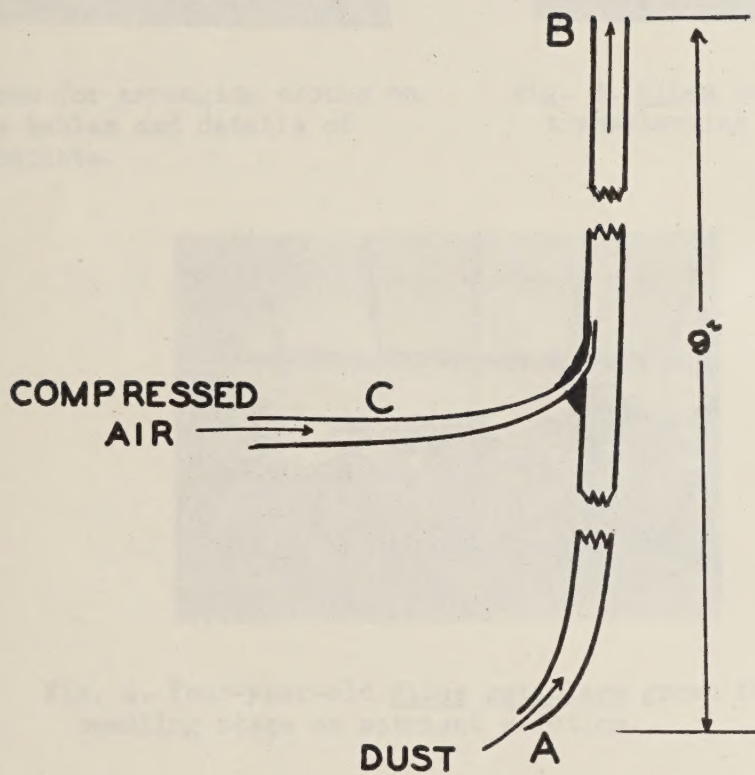


Figure 1.—Diagram of dusting device. A, dust intake; B, nozzle; C, blowpipe, connected with compressed-air line.

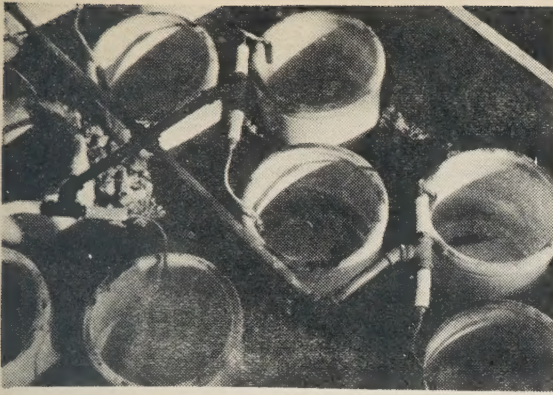


Fig. 2. Scheme for arranging crocks on greenhouse tables and details of aeration outlets.

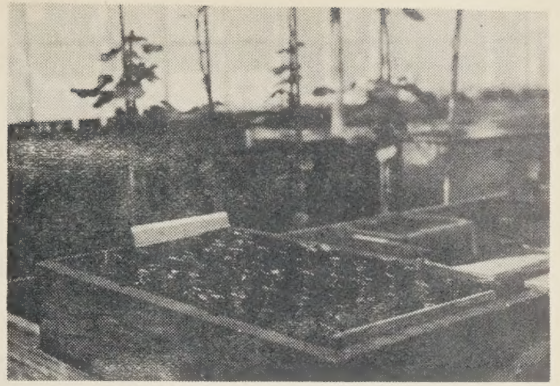


Fig. 3. Ribes seedlings ready for transplanting to nutrient solution.



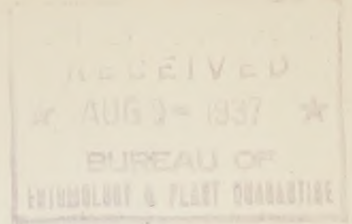
Fig. 4. Four-year-old Ribes petiolare grown from the seedling stage on nutrient solution.



Fig. 5. One plant from those shown in Fig. 2 one month after transplanting from nutrient solution to soil. Roots and tops were heavily pruned before transplanting.



Fig. 6. Typical root development of one of the Ribes petiolare plants shown in Fig. 2. At intervals roots are pruned to a length of about 6 inches.



ET-106

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Correction

The figures in the original circular were incorrectly assembled. The attached sheet contains the correct figure 1 (Diagram Showing Arrangement of Crocks, and Air-washing Equipment, for Culture of Ribes in Nutrient Solution) for ET-106.

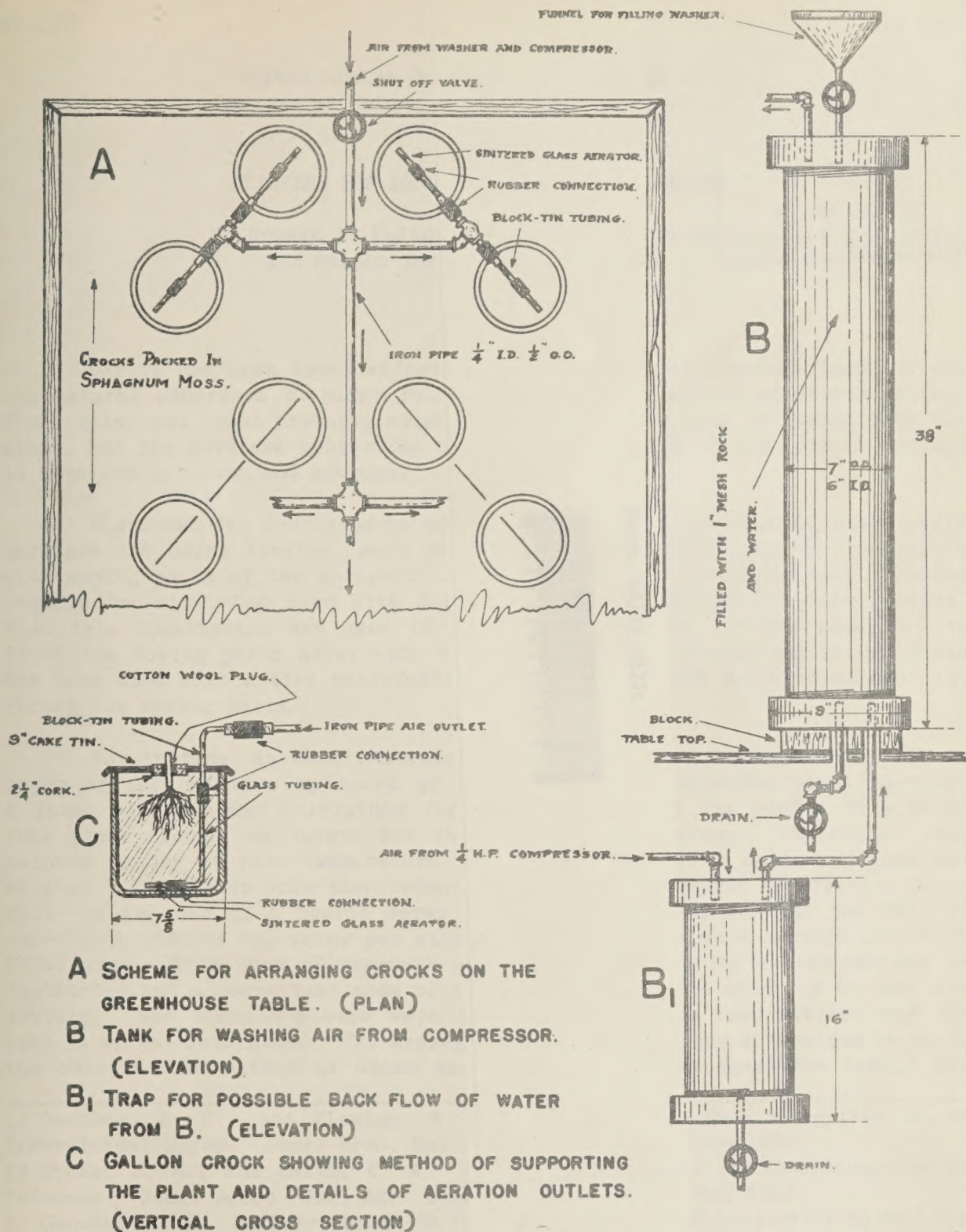


Figure 1. Diagram showing arrangement of crocks, and air-washing equipment, for culture of *Ribes* in nutrient solution.

